

## CHAPTER 2

# LAYOUT AND BENCHWORK

### CHAPTER LEARNING OBJECTIVES

*Upon completing this chapter, you should be able to do the following:*

- *Describe the process used to extract data from blueprints.*
- *Describe the procedures used to draft working drawings for parts manufacture and alteration.*
- *Explain surface characteristics of metal.*
- *Explain how to determine surface finish quality.*
- *Explain layout work.*
- *Explain the procedure used to lay out valve flange bolt holes.*
- *State the process used to hand scrape and blue parts and surfaces for flatness and fit.*
- *Explain filing operation.*
- *Explain the setup and operation of pressure.*
- *Explain the setup and operation of oxyacetylene equipment.*
- *Explain the use of helicoils.*

As an MR, you will repair or help repair many types of equipment used on ships. You will make replacement parts, disassemble and assemble equipment, make layouts of parts to be machined, and do precision work to fit mating parts of equipment. This is known as benchwork and it includes practically all repair work other than actual machining.

This chapter contains information that you need to make effective repairs. *Read Blueprint Reading and Sketching*, NAVEDTRA 10077-F1, for additional information on working drawings. Other sources of information that you should study for details on specific equipment include the *Naval Ships' Technical Manual*, the manufacturers technical manuals, and the training manuals for the equipment you are working on.

As with any shop equipment you must observe all posted safety precautions. Review your equipment operators manual for safety precautions and any chapters of *Navy Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat (OPNAV) Instruction 5100.19B* that pertain to the equipment.

### LIMITS OF ACCURACY

You must work within the limits of accuracy specified on the drawing. A clear understanding of TOLERANCE and ALLOWANCE will help you to avoid small, but potentially dangerous, errors. These terms may seem closely related, but each has a very precise meaning and application. We'll point out the

meanings of these terms and the importance of observing the distinction between them.

## TOLERANCE

In most instances it's impractical and unnecessary to work to the absolute or exact basic dimension. The designer calculates, in addition to the basic dimensions, an allowable variation. The amount of variation, or limit of error permissible, is indicated on the drawing as plus or minus (+) a given amount, such as  $\pm 0.005$  or  $\pm 1/64$ . The difference between the allowable minimum and the allowance maximum dimension is tolerance. For example, in figure 2-1:

Basic dimension = 4

Long limit =  $4 \frac{1}{64}$

Short limit =  $3 \frac{63}{64}$

Tolerance =  $1/32$

When tolerances are not actually specified on a drawing, you can make fairly concrete assumptions concerning the accuracy expected, by using the following principles. For dimensions that end in a fraction of an inch, such as  $1/8$ ,  $1/16$ ,  $1/32$ ,  $1/64$ , the expected accuracy is  $\pm 1/64$  inch. When the dimension is given in decimal form, the following applies:

If a dimension is given as 3.000 inches, the accuracy expected is  $\pm 0.0005$  inch; or if the dimension is given as 3.00 inches, the accuracy expected is  $\pm 0.005$  inch. The  $\pm 0.0005$  is called in shop terms, "plus or minus five ten-thousandths of an inch." The  $\pm 0.005$  is called "plus or minus five thousandths of an inch."

## ALLOWANCE

Allowance is an intentional difference planned in dimensions of mating parts to provide the desired fit. A CLEARANCE ALLOWANCE permits movement between mating parts when they are assembled. For example, when a hole with a 0.250-inch diameter is fitted with a shaft that has a 0.245-inch diameter, the clearance allowance is 0.005 inch. An INTERFERENCE ALLOWANCE is the opposite of a clearance allowance. The difference in dimensions in this case provides a tight fit. You would need force to assemble parts that have an interference allowance. If a shaft with a 0.251-inch diameter is fitted into the hole identified in the preceding example, the difference between the dimensions will give an

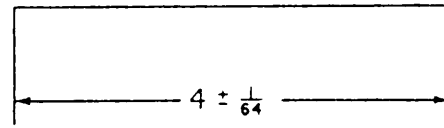


Figure 2-1.—Basic dimension and tolerance.

interference allowance of 0.001 inch. As the shaft is larger than the hole, force is necessary to assemble the parts.

What is the relationship between tolerance and allowance? When you manufacture mating parts, you must control the tolerance of each part so the parts will have the proper allowance when they are assembled. Here's an example. A hole 0.250 inch in diameter with a tolerance of 0.005 inch ( $\pm 0.0025$ ) is prescribed for a job. The shaft to be fitted in the hole is to have a clearance allowance of 0.001 inch. You must finish the hole within the limits and determine the required size of the shaft exactly before you can make the shaft. If you finish the hole to the upper limit of the basic dimension (0.2525 inch), you would machine the shaft to 0.2515 inch or 0.001 inch smaller than the hole. If the dimension of the shaft was given with the same tolerance as the hole there would be no control over the allowance between the parts. As much as 0.005-inch allowance (either clearance or interference) could result.

To retain the required allowance and still permit some tolerance in the dimensions of the mating parts, the tolerance is limited to one direction on each part. This single direction (unilateral) tolerance stems from the basic hole system. If a clearance allowance is required between mating parts, the hole may be larger but not smaller than the basic dimension; the part that fits into the opening may be smaller but not larger than the basic dimension. Thus, shafts and other parts that fit into a mating opening have a minus tolerance only, while the openings have a plus tolerance only. If an interference allowance between the mating parts is required, the situation is reversed; the opening can be smaller but not larger than the basic dimension, while the shaft can be larger but not smaller than the basic dimension. Therefore, you can expect to see a tolerance such as  $+0.005$ ,  $-0$ , or  $+0$ ,  $-0.005$ , but with the required value not necessarily 0.005. You can get a better understanding of a clearance allowance, or an interference allowance, if you make a rough sketch of the piece and add dimensions to the sketch where they apply.

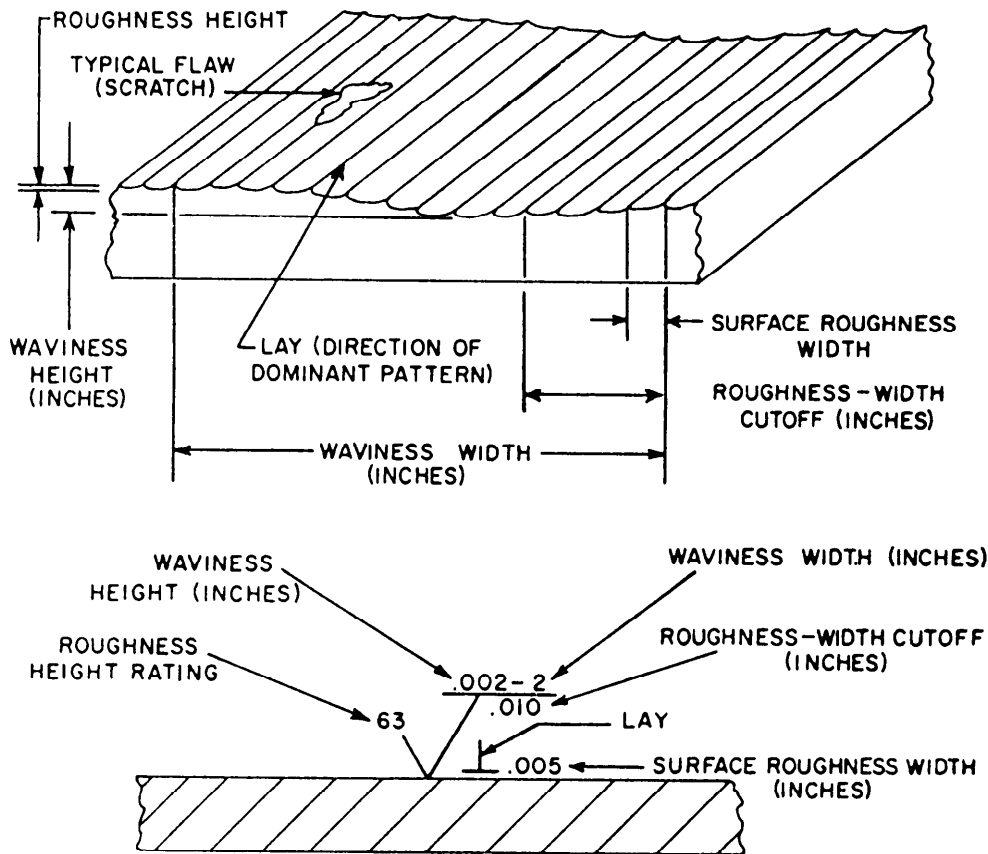


Figure 2-2.—Relation of symbols to surface characteristics.

## SURFACE CHARACTERISTICS OF METAL

While you must control the finished dimensions of a part, you also must consider the degree of smoothness, or surface roughness. Both are very important in the efficiency and life of a machine part.

A finished surface may appear to be perfectly flat; but, when you examine it with surface finish measuring instruments, you will find it is formed of irregular waves. On top of these waves are other smaller waves that we'll call peaks and valleys. You'll measure these peaks and valleys to determine the surface roughness measurements of height and width. Measure the larger waves to give the waviness height and width measurements. Figure 2-2 illustrates the general location of the various areas for surface finish measurements and the relation of the symbols to the surface characteristics.

Surface roughness is the measurement of the finely spaced surface irregularities; their height, width, direction, and shape establish the predominant surface pattern. The irregularities are caused by the cutting or abrading action of the machine tools that have been used to obtain the surface. The basic

roughness symbol that you'll find on the drawing is a check mark. This symbol is supplemented with a horizontal extension line above it when requirements such as waviness width or contact area must be specified in the symbol. A drawing that shows only the basic symbol indicates that the surface finish requirements are detailed in the NOTES block. The roughness height rating is placed at the top of the short leg of the check (view A, fig. 2-3). If only one

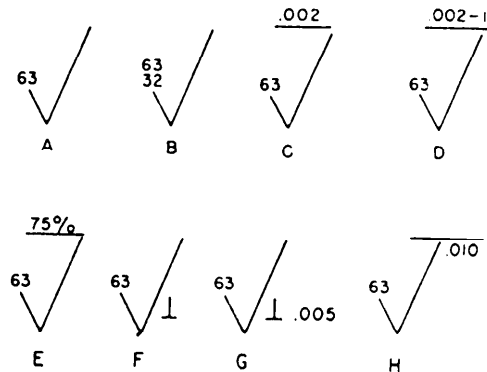


Figure 2-3.—Symbols used to indicate surface roughness, waviness, and lay.

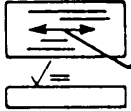
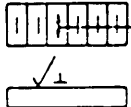

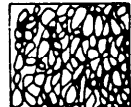


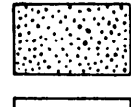
number is shown for roughness height, it is the maximum permissible roughness height rating; if two are shown, the top number is the maximum (view B, fig. 2-3). A point to remember is that the smaller the number in the roughness height rating, the smoother the surface.

Waviness height values are shown directly above the extension line at the top of the long leg of the basic check (view C, fig. 2-3). Waviness width values are placed to the right of the waviness height values (view D, fig. 2-3). Where minimum requirements for contact or bearing surfaces must be shown, the percentage is placed at the top of the long leg of the

basic check (view E, fig. 2-3). The NOTES block of the drawing will show any further surface finish requirements, such as waviness width or height.

Lay is the direction of the predominant surface pattern produced by the tool marks. The symbol indicating lay is placed to the right and slightly above the point of the surface roughness symbol, as shown in view F of figure 2-3. (Fig. 2-4 shows the seven symbols that indicate the direction of lay.)

The roughness width value is shown to the right of and parallel to the lay symbol. The roughness width cutoff is placed immediately below the extension line and to the right of the long leg of the

LAY SYMBOL	DESIGNATION	EXAMPLE
=	LAY PARALLEL TO THE BOUNDARY LINE REPRESENTING THE SURFACE TO WHICH THE SYMBOL APPLIES.	 DIRECTION OF TOOL MARKS
⊥	LAY PERPENDICULAR TO THE BOUNDARY LINE REPRESENTING THE SURFACE TO WHICH THE SYMBOL APPLIES.	 DIRECTION OF TOOL MARKS
X	LAY ANGULAR IN BOTH DIRECTIONS TO BOUNDARY LINE REPRESENTING THE SURFACE TO WHICH SYMBOL APPLIES.	 DIRECTION OF TOOL MARKS
M	LAY MULTIDIRECTIONAL	 DIRECTION OF TOOL MARKS
C	LAY APPROXIMATELY CIRCULAR RELATIVE TO THE CENTER OF THE SURFACE TO WHICH THE SYMBOL APPLIES.	 DIRECTION OF TOOL MARKS
R	LAY APPROXIMATELY RADIAL RELATIVE TO THE CENTER OF THE SURFACE TO WHICH THE SYMBOL APPLIES.	 DIRECTION OF TOOL MARKS
P <sup>3</sup>	LAY PARTICULATE, NON-DIRECTIONAL, OR PROTUBERANT	 DIRECTION OF TOOL MARKS

<sup>3</sup> The "P" symbol is not currently shown in ISO Standards. American National Standards Committee B46 (Surface Texture) has proposed its inclusion in ISO 1302—"Methods of Indicating surface texture on drawings."

Figure 2-4.—Symbols indicating the direction of lay.

MACHINE OPERATION	ROUGHNESS HEIGHT (MICROINCHES)										
	2000	1000	500	250	125	63	32	16	8	4	2
FLAME CUTTING											
SAWING											
PLANING											
DRILLING											
MILLING											
BROACHING											
REAMING											
BORING, TURNING											
ROLLER BURNISHING											
GRINDING											
HONING											
POLISHING											
LAPPING											
SAND CASTING											

Figure 2-5.—Roughness height values for machine operations.

basic check mark. These symbols for roughness width are shown in view G and H of figure 2-3.

Figure 2-5 shows a sampling of some roughness height values that can be obtained by the different machine operations.

### READING SURFACE FINISH QUALITY

A surface finish is seldom flat. We said earlier that close examination with surface finish measuring instruments shows the surface to be formed of irregular waves. On top of the waves are other smaller irregularities known as peaks and valleys. We will now discuss several ways to evaluate surface finish.

### VISUAL INSPECTION

There are occasions when visual comparison with the naked eye will show that one surface is rougher than the other. This is possible only in cases of widely differing surfaces. You also can use visual inspection to detect large cracks in metal.

You can make a visual comparison with illuminated magnifiers (fig. 2-6).

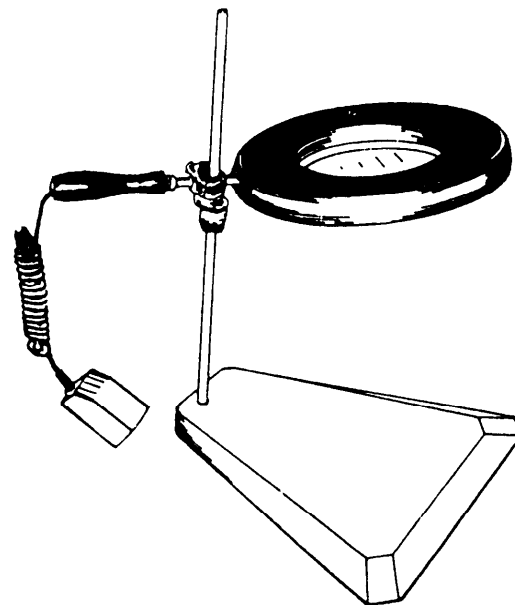


Figure 2-6.—Magnifier with illuminator for surface inspection.

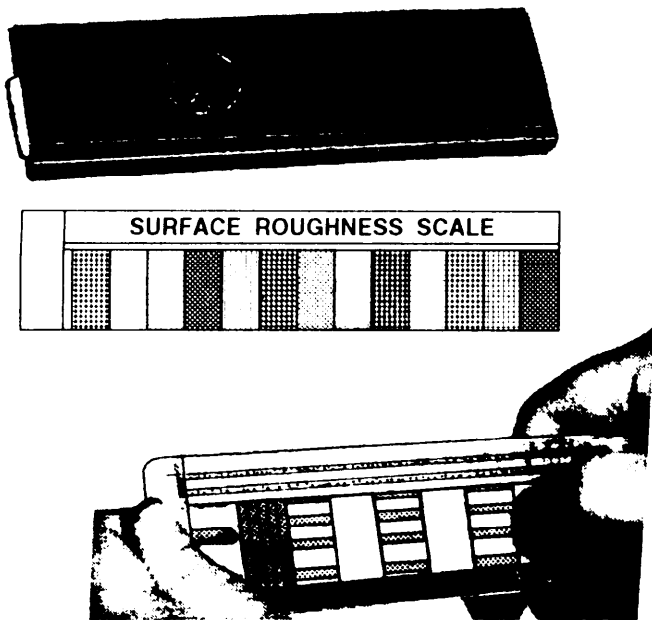


Figure 2-7.—Master roughness scales.

## TOUCH COMPARISON

Move a fingernail along the surface of the job and make a mental note of the amount of resistance and the depth of irregularities. Then, move your fingernail across a series of master roughness scales that have numbers corresponding to their measurement in microinches (fig. 2-7). The machine finish must compare satisfactorily with the correct master.

## INTERFERENCE MICROSCOPE INSPECTION

This inspection requires you to use a microscope with an optical flat plate and a monochromatic light (fig. 2-8). The microscope allows you to see the height of the surface irregularity in light reflected between the microscope objective and surface of the work. The interference fringes indicate the intersection of the wave fronts reflected between the work and the front surface of the microscope objective. The distance between the fringes represents 11 microinches (11 millionths of an inch). The interference microscope is used primarily in laboratories, but you should be aware of it in case you encounter it during your career.

## PROFILOMETER

The profilometer (fig. 2-9) is the instrument most commonly used to find the degree of surface

roughness. It uses the tracer method and actually measures the differences in the depth of the surface irregularity.

The two main units of the profilometer are the tracer and the amplimeter. Tracers are made in several designs to measure a variety of shapes. The tracer has a stylus with a very small radius at its tip. As the tracer is moved across the surface being measured, the stylus follows the contours of the irregularities left by the machining operation. The up and down movements of the tracer stylus are converted into a small fluctuating voltage. The voltage is fed into the amplimeter where it is amplified to actuate the microinches meter on the front panel (fig. 2-10). The meter shows the variations in the average roughness height in microinches.

A motor-driven unit, the motorace (fig. 2-9), provides mechanical movement of the tracer and its stylus when manual operation is not practical.

You don't need technical knowledge or special skill to operate instruments that are used to check for surface roughness. You can set up the instrument on a bench or cabinet beside the production machine and

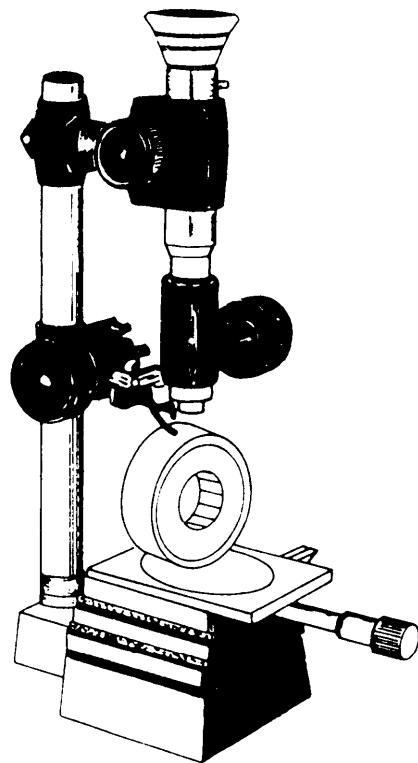
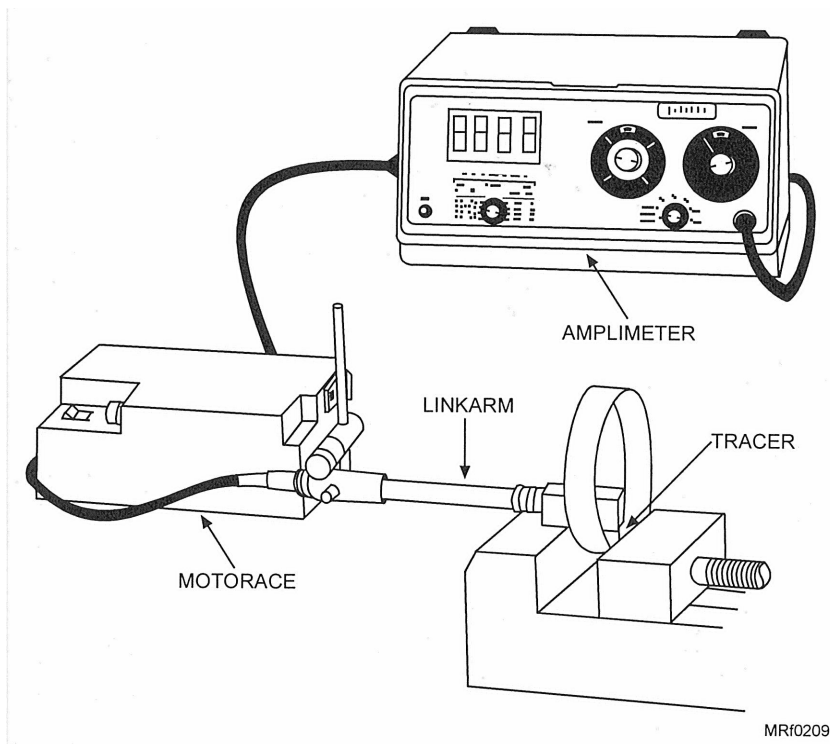


Figure 2-8.—The interference (surface-finish) microscope.



**Figure 2-9.—The profilometer measuring the surface roughness of an internal diameter.**

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**Figure 2-10.—The profilometer amplimeter control panel.**

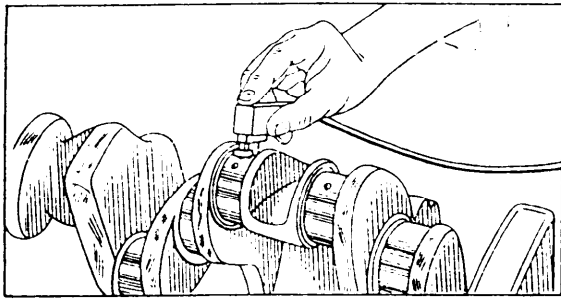


Figure 2-11.—Checking surface finish on the machine.

check the workpiece manually while it is in the machine (fig. 2-11).

## SURFACE ANALYZER

The surface analyzer (fig. 2-12) is a practical shop instrument designed for the accurate measurement of surface finish roughness. Like the profilometer, it measures the irregularities of the surface finish and records them in microinches. This is done by a tracer stylus, which registers the rise and fall of the peaks and valleys on the finished surfaces. These variations are amplified and indicated on the electrical meter, calibrated to read in microinches.

## LAYOUT METHODS

*Layout* is the term used to describe the marking of metal surfaces to provide an outline for machining. A layout is comparable to a single view (end, top, or side) of a part that is sketched directly on the workpiece. The degree of difficulty depends on the intricacies of the part to be laid out and the number of operations required to make the part. A flange layout, for example, is relatively simple as the entire layout can be made on one surface of the blank flange. However, an intricate casting may require layout lines on more than one surface. This requires careful study and concentration to make sure the layout will have the same relationships as those shown on the drawing (or sample) that you are using.

When a part must be laid out on two or more surfaces, you may need to lay out one surface and machine it to size before using further layout lines. This prevents removal of layout lines on one surface while you are machining another.

The process of computing and transferring dimensions will help you become familiar with the

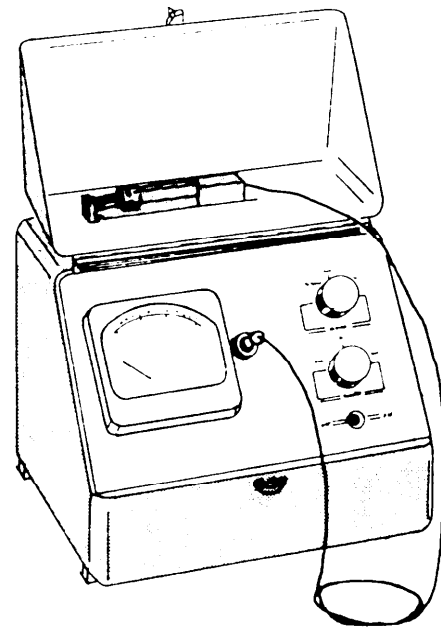


Figure 2-12.—Surface analyzer.

relationship of the surfaces. That understanding will help you plan the sequence of machining operations.

Mechanical drawing and layout are closely related subjects; knowledge of one will help you understand the other. You also must know general mathematics, trigonometry, and geometry, and how to select and use tools for jobs related to layout and mechanical drawing. Study *Mathematics*, Volume I, NAVEDTRA 10069-D1; *Mathematics*, Volume 2-A, NAVEDTRA 10062; *Use and Care of Hand Tools and Measuring Tools*, NAVEDTRA 12085, and *Blueprint Reading and Sketching*, NAVEDTRA 10077-F7, for additional information.

The following information applies to practically all layouts. Layout lines are formed by using a reference edge or point on the stock or by using the surface plate as a base. Study carefully the section on geometric construction. It will help you make layouts when you can't use a reference edge of the stock or a surface plate mounting of the stock.

## LINES SQUARE OR PARALLEL TO EDGES

When scribing layout lines on sheet metal, hold the scratch awl, or scribe, as shown in figure 2-13. Lean it toward the direction in which it will be moved and away from the straightedge. This will help you scribe a smooth line that will follow the edge of the



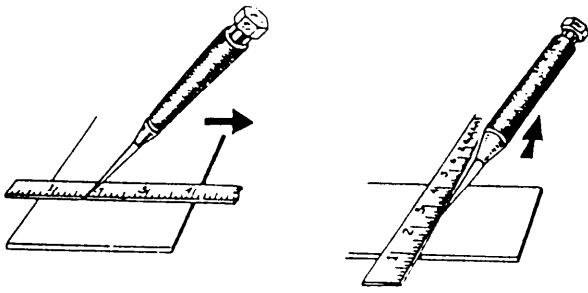


Figure 2-13.—Using a scribe.

straightedge, template, or pattern at its point of contact with the surface of the metal.

To scribe a line on stock with a combination square, place the squaring head on the edge of the stock, as shown in figure 2-14. Draw the line along either edge of the blade. The line will be square with the edge of the stock against which the squaring head is held; that is, the angle between the line and the edge will be  $90^\circ$ .

To draw lines parallel to an edge using a combination square, extend the blade from the squaring head the required distance, such as the 2-inch setting shown in figure 2-15. Secure the blade at this position. Scribe a line parallel to the edge of the stock by holding the scratch awl, or scribe, at the end of the blade as you move the square along the edge. All lines so scribed, with different blade settings, will be parallel to the edge of the stock and parallel to each other.

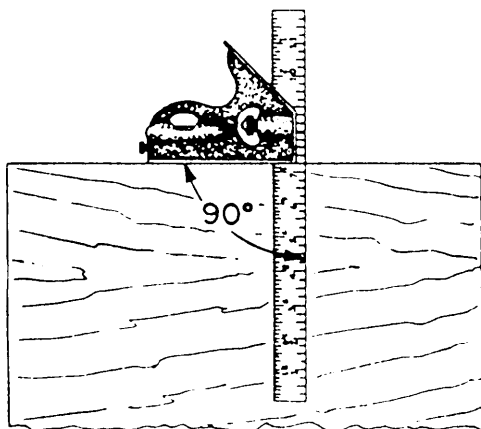


Figure 2-14.—Using the combination square.

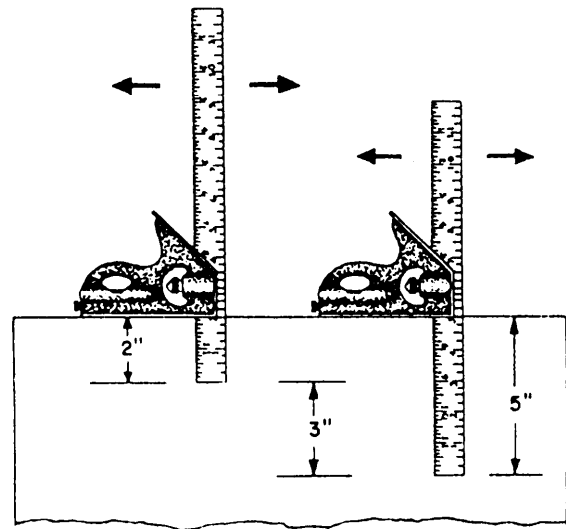


Figure 2-15.—Laying out parallel lines with a combination square.

To scribe a line parallel to an edge with a hermaphrodite caliper, hold the caliper, as shown in figure 2-16, so the curved leg maintains contact with the edge while the other leg scribes the line. Hold the caliper so the line will be scribed at the desired distance from the edge of the stock.

## FORMING ANGULAR LINES

To lay out a 45-degree angle on stock with a combination square, place the squaring head on the

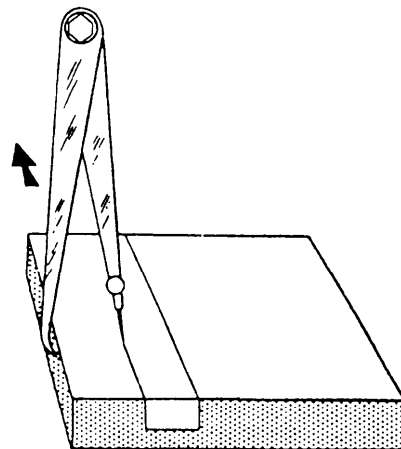


Figure 2-16.—Laying out a parallel line with a hermaphrodite caliper.

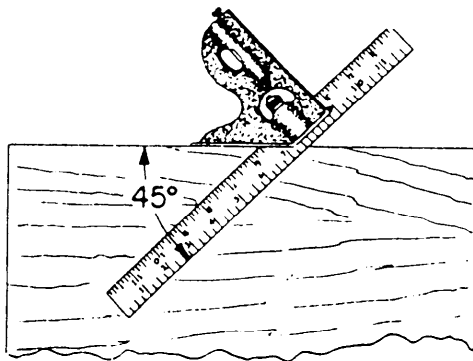


Figure 2-17.—Laying out a 45-degree angle.

edge of the stock, as shown in figure 2-17. Draw the line along either edge of the blade. The line will form a 45-degree angle with the edge of the stock against which the squaring head is held.

To draw angular lines with the protractor head of a combination square, loosen the adjusting screw and rotate the blade so the desired angle lines up with the index mark on the body of the protractor head. The setting shown in figure 2-18 is 60°. Tighten the screw to hold the setting.

Hold the body of the protractor head in contact with the true edge of the work with the blade resting on the surface. Scribe the lines along the edge of the blade on the surface of the work. The angle set on the scale determines the angle laid out on the work. All

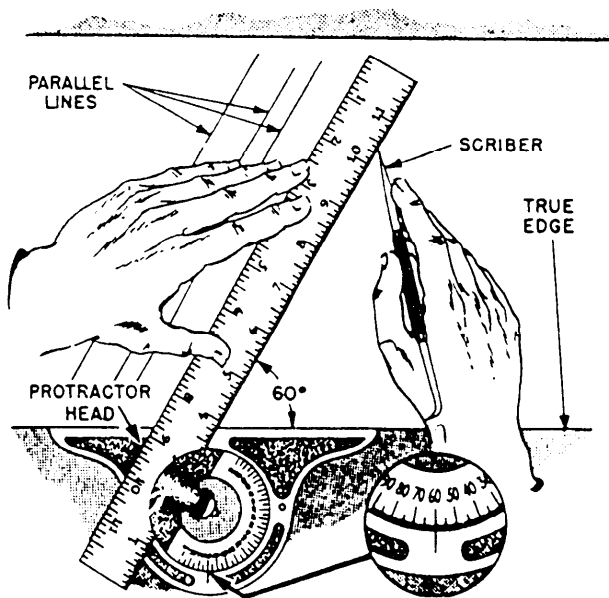


Figure 2-18.—Laying out angular lines.

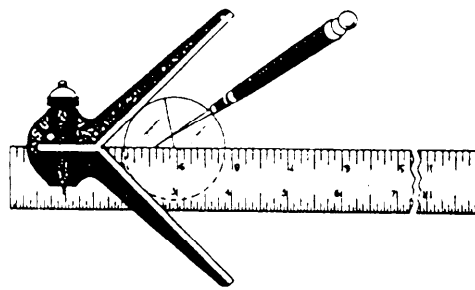


Figure 2-19.—Locating the center of round stock.

lines drawn with the same setting, and from the same true edge of the work, will be parallel lines.

Use the center head and rule, as illustrated in figure 2-19, to locate the center of round stock. To find the center of square and rectangular shapes, scribe straight lines from opposite corners of the workpiece. The intersection of the lines locates the center.

## LAYING OUT CIRCLES AND IRREGULAR LINES

Circles or segments of circles are laid out from a center point. To ensure accuracy, prick-punch the center point to keep the point of the dividers from slipping out of position.

To lay out a circle with a divider, take the setting of the desired radius from the rule, as shown in figure 2-20. Note that the 3-inch setting is being taken AWAY from the end of the rule. This reduces the chance of error as each point of the dividers can be

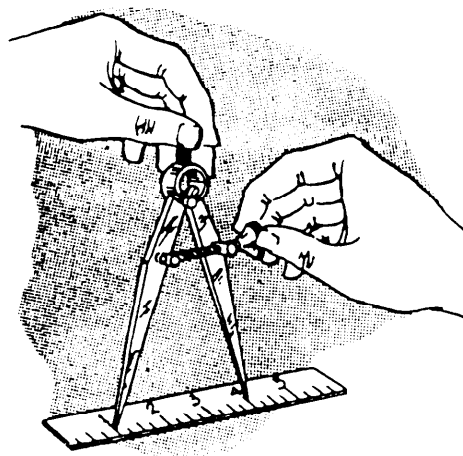


Figure 2-20.—Setting a divider to a dimension.

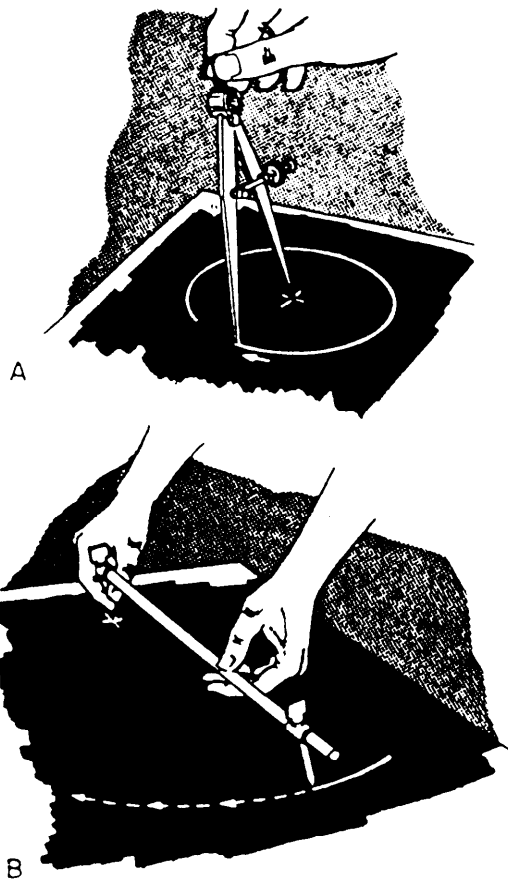


Figure 2-21.—Laying out circles.

set on a graduation. Place one leg of the divider at the center of the proposed circle. Then, lean the tool in the direction it will be rotated and rotate it by rolling the knurled handle between your thumb and index finger (view A of fig. 2-21).

When setting trammel points, shown in view B of figure 2-21, follow the same directions as for a divider. You may need a steel tape to set the trammel points.

To lay out a circle with trammel points, hold one point at the center and lean the tool in the direction you plan to move the other point. Then, swing the arc, or circle, as shown in view B of figure 2-21.

To transfer a distance measurement with trammel points, hold one point as you would to lay out a circle. Then, swing a small arc with the other point opened to the desired distance.

Scribing an irregular line to a surface is a skill used to fit a piece of stock to a curved surface, as shown in figure 2-22. In view A you see the complete

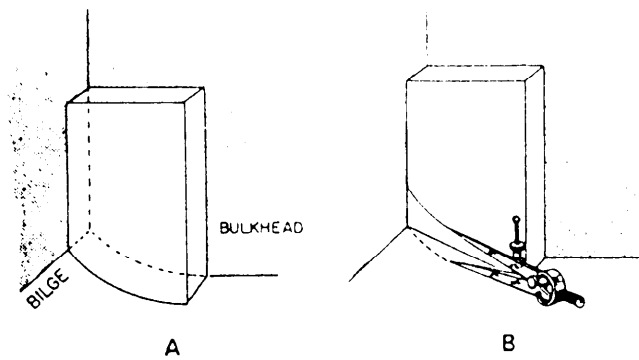


Figure 2-22.—Laying out an irregular line from a surface.

fit. In view B the divider has scribed a line from left to right. When scribing horizontal lines, keep the legs of the divider plumb (one above the other). When scribing vertical lines, keep the legs level. To scribe a line to an irregular surface, set the divider so one leg will follow the irregular surface and the other leg will scribe a line on the material that is being fitted to the irregular surface. (See view B of fig. 2-22.)

## USING THE SURFACE PLATE

Use the surface plate with such tools as parallels, squares, V-blocks, surface gauges, angle plates, and sine bars to make layout lines. Use angle plates similar to the one shown in figure 2-23 to mount work at an angle on the surface plate. To set the angle of the angle plate, use a protractor and rule of the combination square set or use a vernier protractor.

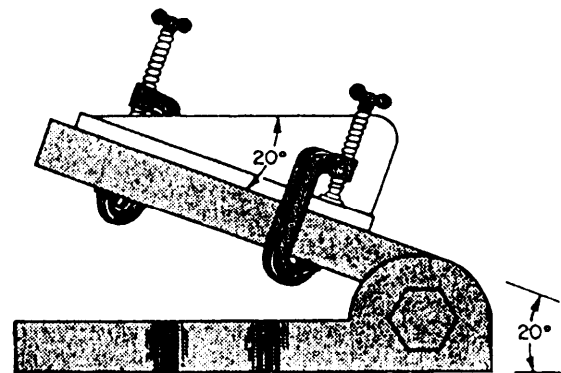


Figure 2-23.—Angle plate.

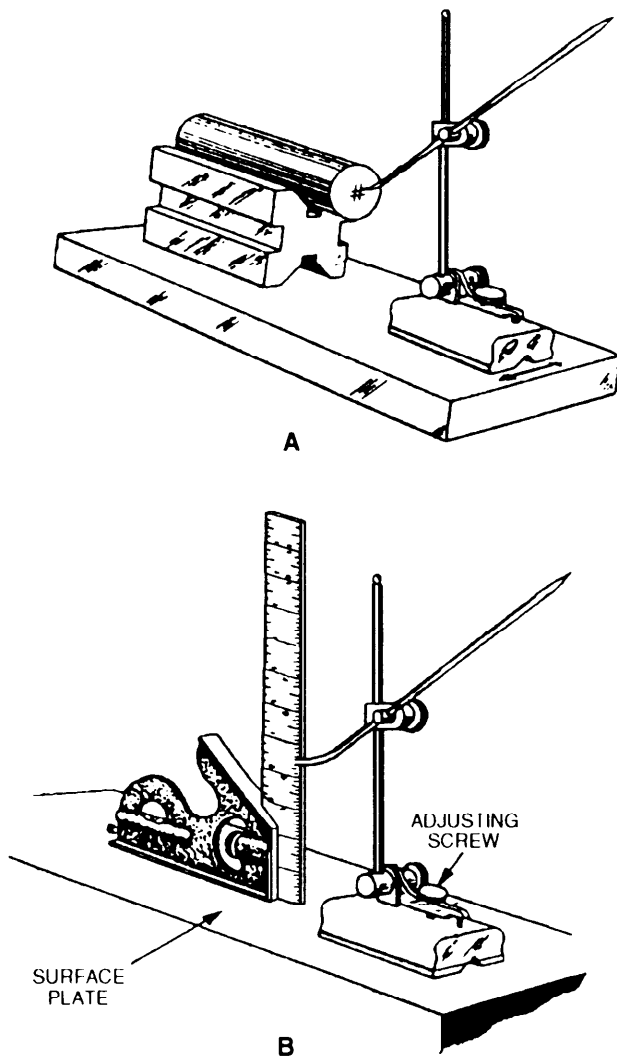


Figure 2-24.—Setting and using a surface gauge.

View A of figure 2-24 shows a surface gauge V-block combination used to lay out a piece of stock. To set a surface gauge for height, first clean the top of the surface plate and the bottom of the surface gauge.

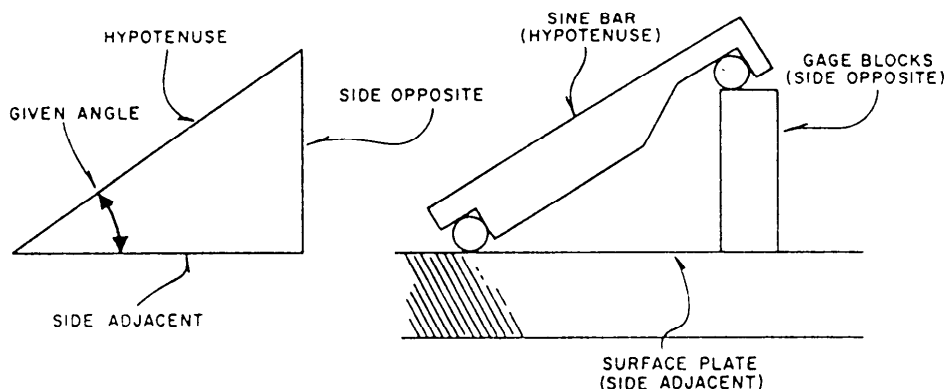


Figure 2-25.—Setup of the sine bar.

Then, place the squaring head of a combination square, as shown in view B. Secure the scale so the end is in contact with the surface of the plate. Move the surface gauge into position.

## USING THE SINE BAR

A sine bar is a precisely machined tool steel bar used with two steel cylinders. In the type shown in figure 2-25, the cylinders establish a precise distance of either 5 inches or 10 inches from the center of one to the center of the other, depending upon the model used. The bar itself has accurately machined parallel sides, and the axes of the two cylinders are parallel to the adjacent sides of the bar within a close tolerance. Equally close tolerances control the cylinder roundness and freedom from taper. The slots or holes in the bar are for convenience in clamping workpieces to the bar. Although the illustrated bars are typical, there is a wide variety of specialized shapes, widths, and thicknesses.

The sine bar itself is very easy to set up and use. You do need a basic knowledge of trigonometry to understand how it works. When a sine bar is set up, it always forms a right triangle. A right triangle has one 90-degree angle. The base of the triangle, formed by the sine bar, is the surface plate, as shown in figure 2-25. The side opposite is made up of the gauge blocks that raise one end of the sine bar. The hypotenuse is always formed by the sine bar, as shown in figure 2-25. The height of the gauge block setting may be found in two ways. The first method is to multiply the sine of the angle needed by the length of the sine bar. The sine of the angle may be found in any table of natural trigonometric functions. For example, if you had to set a 10-inch sine bar to check a  $30^{\circ}5'$  angle on a part, you would first go to a table of

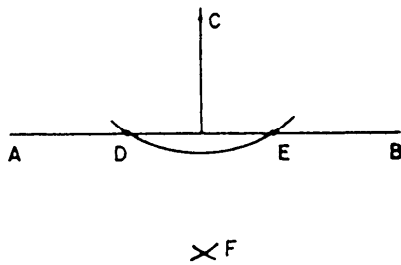


Figure 2-26.—Layout of a perpendicular from a point to a line.

natural trigonometric functions and find the sine of  $30^{\circ}5'$ . Then, multiply the sine value by 10 inches ( $0.50126 \times 10 = 5.0126$ ) to find the height of the gauge blocks. The second method is to use a table of sine bar constants. These tables give the height setting for any given angle (to the nearest minute) for a 5-inch sine bar. Tables are not normally available for 10-inch bars because it is easy to use the sine of the angle and move the decimal point one place to the right.

Although sine bars appear to be rugged, you should give them the same care as gauge blocks. Since they are used with other tools or parts that are heavy, they are subject to rough usage. Remove or repair scratches, nicks, and burrs. Keep them clean from abrasive dirt and sweat and other corrosive agents. Make regular inspections to locate defects before they affect the accuracy of the bar. When you store sine bars for extended periods, clean all bare metal surfaces and then cover them with a light film of oil. Place a cover over the sine bar to prevent accidental damage and to discourage corrosion.

## GEOMETRIC CONSTRUCTION OF LAYOUT LINES

Sometimes you will need to scribe a layout that cannot be made with conventional layout methods. For example, you cannot readily make straight and angular layout lines on sheet metal with irregular edges by using a combination square set. Neither can you mount sheet metal on angle plates in a manner that permits scribing angular lines. Geometric construction is the answer to this problem.

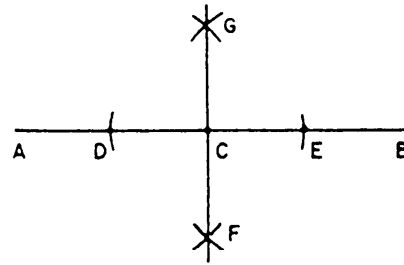


Figure 2-27.—Layout of a perpendicular from a point on a line.

Use a divider to lay out a perpendicular FROM a point TO a line, as shown in figure 2-26. Lightly prick-punch point C, then swing any arc from C that will intersect line AB. Prick-punch intersections D and E, as in the figure. With D and E as centers, scribe two arcs that intersect at a point such as F. Place a straightedge on points C and F. The line drawn along this straightedge from point C to line AB will be perpendicular ( $90^{\circ}$ ) to line AB.

Use a divider to lay out a perpendicular FROM a point ON a line, as shown in figure 2-27. Lightly prick-punch point C on line AB. Then, set the divider to any distance to scribe arcs that intersect AB at D and E with C as the center. Punch C and E lightly. With D and E as centers and with the setting of the divider increased somewhat, scribe arcs that cross at points such as F and G. The line drawn through F and G will pass through point C and be perpendicular to line AB.

To lay out parallel lines with a divider, set the divider to the selected dimension. Then, referring to figure 2-28, from any points (prick-punched) such as C and D on line AB, swing arcs EF and GH. Then, draw line IJ tangent to these two arcs and it will be parallel to line AB and at the selected distance from it.

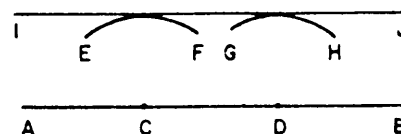


Figure 2-28.—Layout of a parallel line.

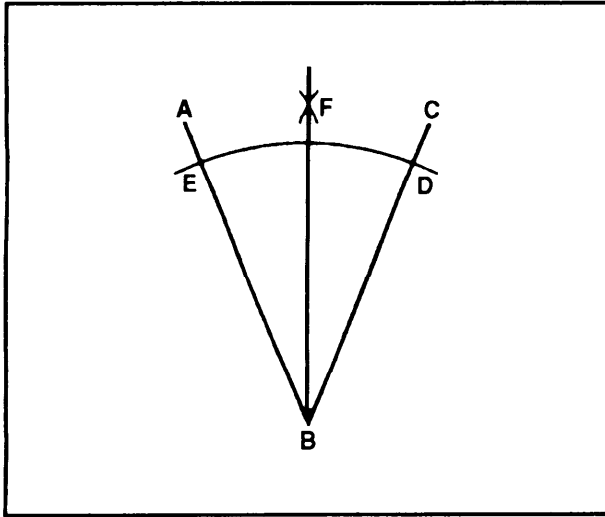


Figure 2-29.—Bisecting an angle.

To bisect an angle, let's assume angle ABC (fig. 2-29) is given. With B as a center, draw an arc cutting the sides of the angle at D and E. With D and E as centers, and with a radius greater than half of arc DE, draw arcs intersecting at F. Then, draw a line from B through point F to bisect angle ABC.

## LAYING OUT VALVE FLANGE BOLT HOLES

Before describing the procedure used to make valve flange layouts, we need to clarify the terminology used in the description. Figure 2-30 shows a valve flange with the bolt holes marked on the bolt circle. The straight-line distance between the centers of two adjacent holes is called the **PITCH CHORD**. The bolt hole circle itself is called the **PITCH CIRCLE**. The vertical line across the face of the flange is the **VERTICAL BISECTOR**, and the horizontal line across the face of the flange is the **HORIZONTAL BISECTOR**.

The bolt holes center on the pitch circle and are equal in distance. The pitch chord between any two adjacent holes is exactly the same as the pitch chord between any other two adjacent holes. Note that the two top holes and the two bottom holes straddle the vertical bisector; the vertical bisector cuts the pitch chord for each pair exactly in half. This is the standard method used to place the holes for a 6-hole flange. In the 4-, 8-, or 12-hole flange, the bolt holes straddle both the vertical and horizontal bisectors. This system of hole placement permits a valve to be

installed in a true vertical or horizontal position. This assumes that the pipe flange holes are also in the standard location on the pitch circle. Before you do a valve flange layout job, find out whether the holes are to be placed in the standard position. If you are working on a "per sample" job, follow the layout of the sample.

Assuming you are sure of the size and number of holes and the radius of the pitch circle, use the following procedure to set up the layout for straight globe or gate valve flanges.

1. Fit a fine grain wood plug into the opening in each flange. (See fig. 2-30.) The plug should fit snugly and be flush with the face of the flange.

2. Apply layout dye to the flange faces, or, if dye is not available, rub chalk on the flange faces to make the drawn lines clearly visible.

3. Locate the center of each flange with a surface gauge, or use a center head and rule combination if the flange diameter is relatively small. (See view A, fig. 2-24 and fig. 2-19.) After you locate the exact center point on each flange, mark the center with a sharp prick-punch.

4. Use dividers to scribe the pitch or bolt circle. Check to see that the pitch circle and the outside edge of the flange are concentric.

5. Draw the vertical bisector. This line must pass through the center point of the flange and must be visually located directly in line with the axis of the valve stem (see fig. 2-30).

6. Draw the horizontal bisector. This line also must pass through the center point of the flange and must be laid out at a right angle to the vertical bisector. (See fig. 2-30 and fig. 2-27.)

Up to this point, the layout is the same for all flanges regardless of the number of holes. Beyond this point, however, the layout differs with the number of holes. The layout for a 6-hole flange is the simplest one and we'll describe it first.

## Six-Hole Flange

Set your dividers exactly to the dimension of the pitch circle radius. Place one leg of the dividers on the point where the horizontal bisector crosses the pitch circle on the right-hand side of the flange. (Point 1 in view A of figure 2-3 1.) Draw a small arc across the pitch circle at points 2 and 6. Next, place one leg of the dividers at the intersection of the pitch

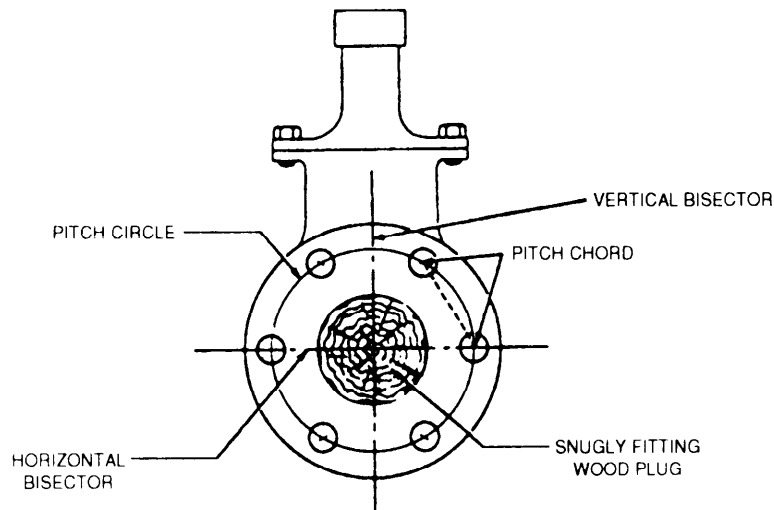


Figure 2-30.—Flange layout terminology.

circle and the horizontal bisector on the left-hand side of the flange point 4. Draw a small arc across the pitch circle line at points 3 and 5. These points (1 to 6) are the centers for the holes. Check the accuracy of the pitch chords. To do this, leave the dividers set exactly as you had them set to draw the arcs. Starting from the located center of any hole, step around the

circle with the dividers. Each pitch chord must be equal to the setting of the dividers. If it is not, you have an error in hole mark placement that you must correct before you center punch the marks for the holes. After you are sure the layout is accurate, center punch the hole marks and draw a circle of appropriate size around each center-punched mark and

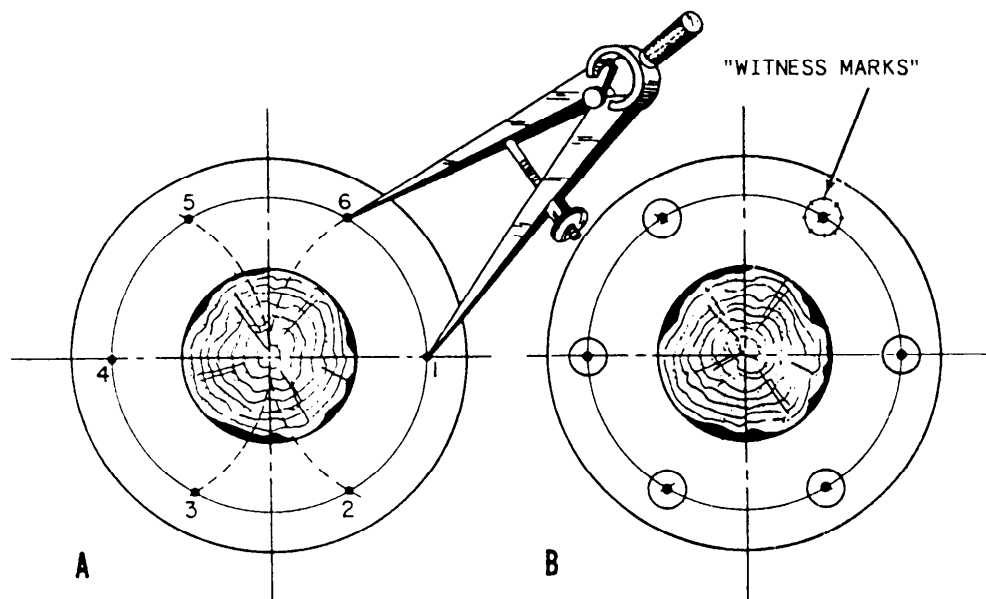


Figure 2-31.—Development of a 6-hole flange.

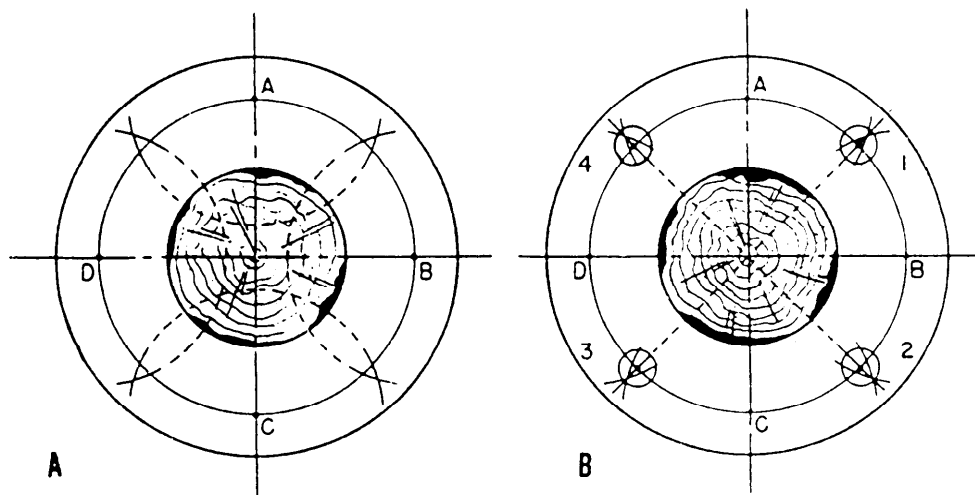


Figure 2-32.—Four-hole flange development.

prick-punch “witness marks” around the circumference, as shown in view B of figure 2-31. These witness marks will be cut exactly in half by the drill to verify a correctly located hole.

#### Four-Hole Flange

Figure 2-32 shows the development for a 4-hole flange layout. Set your dividers for slightly more than half the distance of arc AB. Scribe an intersecting arc across the pitch circle line from points A, B, C, and D, as shown in view A of figure 2-32. Next, draw a short radial line through the point of intersection of each pair of arcs as shown in view B. The points where these lines cross the pitch circle (1, 2, 3, and 4) are the centers for the holes. To check the layout for

accuracy, set your divider for the pitch between any two adjacent holes and step around the pitch circle. If the holes are not evenly spaced, find your error and correct it. When the layout is correct, follow the center-punching and witness-marking procedures described for the 6-hole flange layout.

#### Eight-Hole Flange

Figure 2-33 shows the development of an 8-hole flange. First locate point E by the same method described to locate point 1 in the 4-hole layout. Then, divide arc AE in half by the same method. The midpoint of arc AE is the location for the center of the hole (1). (Set view A of fig. 3-33.) Next, set your dividers for distance A (1), and draw an arc across the

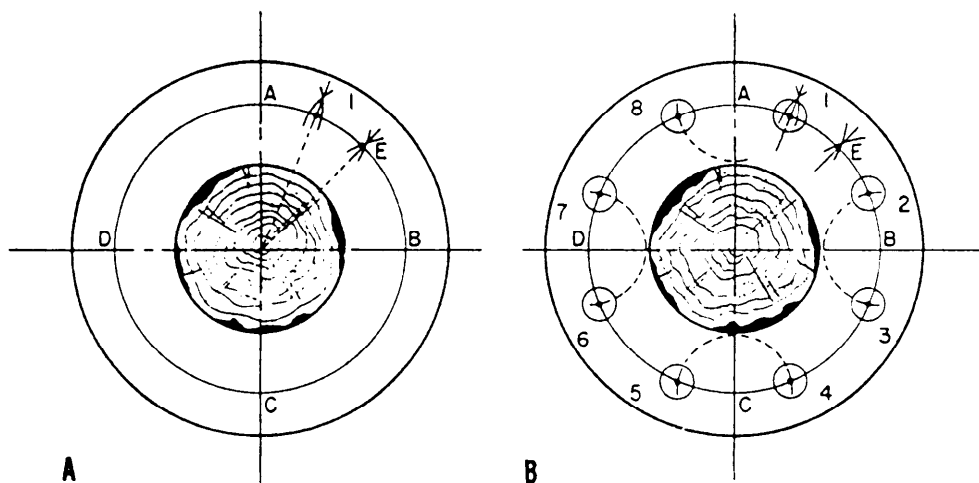


Figure 2-33.—Eight-hole flange development.



pitch circle line from A at point 8; from B at points 2 and 3; from C at 4 and 5; and from D at 6 and 7. (See view B of fig. 2-33.) Now, set your calipers for distance AE and gauge the pitch chord for accuracy. Then, finish the layout as described in the preceding paragraphs.

### Mathematical Determination of Pitch Chord Length

In addition to the geometric solutions given in the preceding paragraphs, you can determine the spacing of valve flange bolt hole centers by simple multiplication, if you know a constant value for the desired number of bolt holes. The diameter of the pitch circle multiplied by the constant equals the length of the pitch chord. The constants for specified numbers of holes are given in table 2-1.

Here is an example of the use of the table. Suppose a flange is to have 9 bolt holes laid out on a pitch circle with a diameter of 10 inches. From the table, select the constant for a 9-hole flange. The pitch diameter (10 inches) multiplied by the appropriate constant (.342) equals the length of the pitch chord (3.420 inches). Set a pair of dividers to measure 3.420 inches, from point to point, and step off around the circumference of the pitch circle to locate the centers of the flange bolt holes. Note, however, that the actual placement of the holes in relation to the vertical and horizontal bisectors is determined separately. (This is of no concern if the layout is for an unattached pipe flange rather than for a valve flange.)

## SCRAPING AND BLUING

Scraping produces a surface that is more accurate in fit and smoother in finish than a machined surface. It is a skill that requires a great deal of practice before you become proficient at it. You need patience, sharp tools, and a light “feel” to scrape a surface until the fit is smooth and uniform.

Some of the tools you will use for scraping will be similar to files without the serrated edges. They are available either straight or with various radii or curves used to scrape an internal surface at selected points. Other scraper tools may look like a paint scraper, possibly with a carbide tip attached. You may find that a scraper you make from material in your shop will be best for the job at hand.

When you scrape a flat surface, you’ll need a surface plate and nondrying Prussian blue. Lightly

Table 2-1.—Constants for Locating Centers of Flange Bolt Holes

No. bolt holes	Constant
3 - - - - -	0.866
4 - - - - -	.7071
5 - - - - -	.5879
6 - - - - -	.5
7 - - - - -	.4338
8 - - - - -	.3827
9 - - - - -	.342
10 - - - - -	.309
11 - - - - -	.2817
12 - - - - -	.2588
13 - - - - -	.2394
14 - - - - -	.2225
15 - - - - -	.2079
16 - - - - -	.195
17 - - - - -	.184
18 - - - - -	.1736
19 - - - - -	.1645
20 - - - - -	.1564

coat the surface plate with blue and move the workpiece over this surface. The blue will stick to the high spots on the workpiece, revealing the areas to be scraped. (See fig. 2-34.) Scrape the areas of the workpiece surface that are blue and check again. Continue this process until the blue coloring shows on the entire surface of the workpiece. To reduce frictional “drag” between mating finished scraped surfaces, rotate the solid surfaces so you make each series of scraper cuts at an angle of 90° to the preceding series. This gives the finished scraped surface a crosshatched or basket weave appearance.

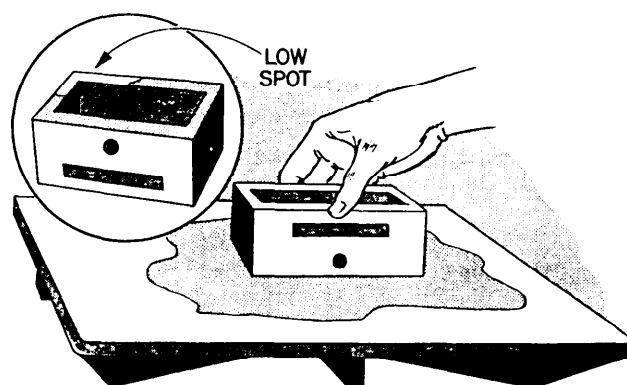
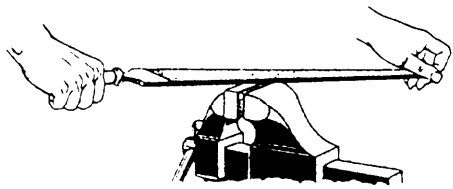
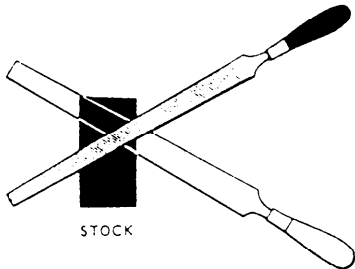


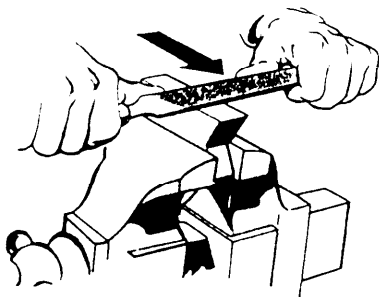
Figure 2-34.—Checking a surface.



A. CROSSFILING A PIECE OF MILD STEEL



B. ALTERNATING POSITIONS WHEN FILING



C. DRAWFILING A SMALL PART

Figure 2-35.—Filing.

The crosshatched method helps you see where you have scraped the part.

## FILING

A file is nearly indispensable when you work with metal. You may be crossfiling, drawfiling, precision filing, or using a file card. Let's examine these operations.

### CROSSFILING

Figure 2-35, view A shows a piece of mild steel being crossfiled. This means that the file is being moved across the surface of the work in a crosswise direction. Keep your feet spread apart to steady

yourself as you file with slow, full-length, steady strokes. The file cuts as you push it. Ease up on the return stroke to keep from dulling the teeth. View B of figure 2-35 shows the alternate positions of the file when an exceptionally flat surface is required. Using either position first, file across the entire length of the stock. Then, using the other position, file across the entire length of the stock again. Because the teeth of the file pass over the surface of the stock from two directions, the high spots and low spots will be visible after filing in both positions. Continue filing first in one direction and then the other until the surface has been filed flat. Test the flatness with a straightedge, or where precision is required, with Prussian blue and a surface plate.

## DRAWFILING

Drawfiling produces a finer surface finish than crossfiling. Small parts, as shown in view C of figure 2-35, are best held in a vise. Hold the file as shown in the figure. Notice that the arrow indicates that the cutting stroke is away from you when the handle is held in the right hand. If the handle is held in the left hand, the cutting stroke will be toward you. Lift the file away from the surface of the work on the return stroke. When drawfiling no longer improves the surface texture, wrap a piece of abrasive cloth around the file and polish the surface, as shown in figure 2-36.



D. POLISHING METAL WITH ABRASIVE CLOTH WRAPPED AROUND A FILE

Figure 2-36.—Polishing.

## USING THE FILE CARD AND BRUSH

As you file, the teeth of the file may become clogged with metal filings and scratch your work. This is known as PINNING. You can prevent pinning by keeping the file teeth clean. Rubbing chalk between the teeth will help prevent pinning, but the best method is to clean the file often with a file card and brush. This tool (fig. 2-37) has fine wire bristles on one side and a stiff brush on the other side. Use the file card with a pulling motion, holding it parallel to the rows of teeth. Then, use the brush to remove any loose filings.

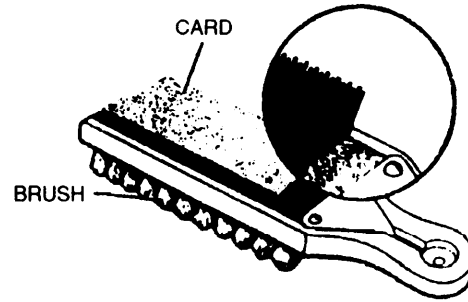


Figure 2-37.—File card with brush.

## HYDRAULIC AND ARBOR PRESSES

Hydraulic and arbor presses are used in many Navy machine shops. They are used to force broaches through parts, assemble and disassemble equipment with force-fitted parts, and many other shop projects.

Arbor presses are usually bench mounted with a gear and rack arrangement. Use them for light pressing jobs, such as to press arbors or mandrels into a part or to force a small broach through a part.

Hydraulic presses can be either vertical or horizontal, although the vertical design is probably more common and versatile. A hydraulic press can generate pressure ranging from about 10 to 100 tons in most Navy machine shops. The pressure can be exerted by either a manually operated pump or an electrohydraulic pump.

Regardless of the type of press equipment you use, be sure to operate it correctly. The only way you can determine the amount of pressure a hydraulic press exerts is by watching the pressure gauge. A part being pressed can reach the breaking point without any visible indication that too much pressure is being applied. When using the press, you must consider the interference allowance between mating parts; corrosion and marred edges; and overlooked fastening devices, such as pins, setscrews, and retainer rings.

Observe the following safety precautions when you use presses:

- Always wear safety glasses and a face shield.
- Make sure the work is adequately supported.

- Place the ram in contact with the work by hand, so the work is positioned accurately in alignment with the ram.

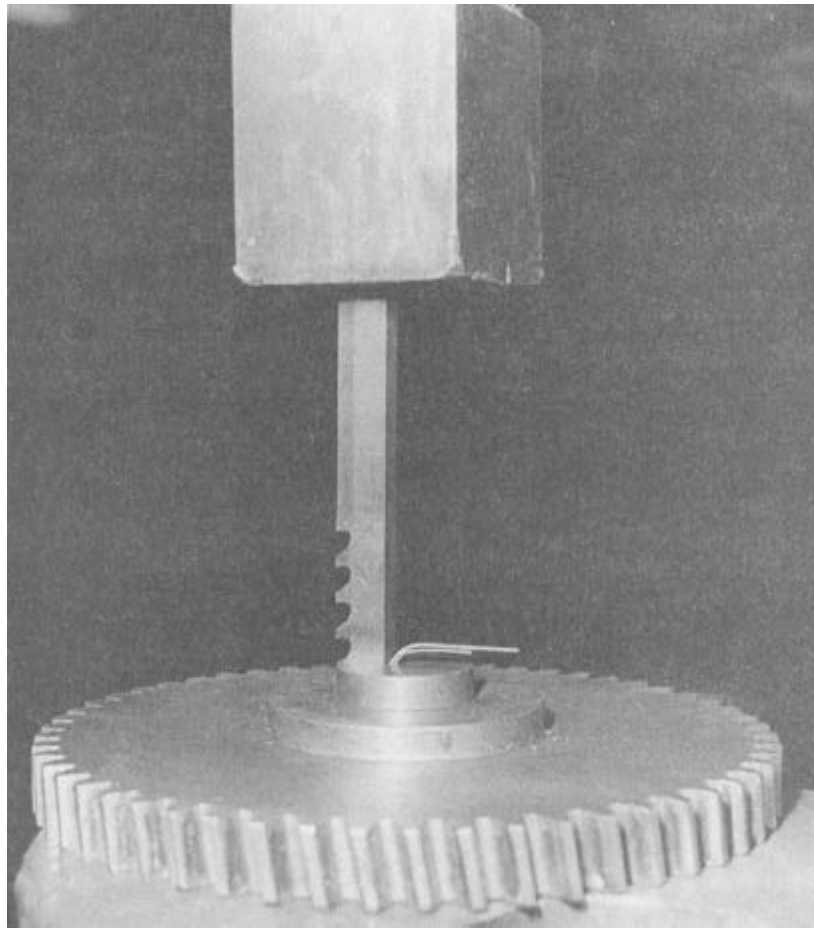
- Use a piece of brass or other material (slightly softer than the workpiece) between the face of the ram and the work to prevent mutilation of the surface of the workpiece.

- Watch the pressure gauge when you use a hydraulic press. You cannot determine the pressure exerted by “feel.” If you begin to apply excessive pressure, release the pressure and double check the work to find the cause.

- When pressing parts together, if possible, use a lubricant between the mating parts to prevent seizing.

Most handbooks for machinists have information concerning the pressure required to force fit two mating parts together. The distance the parts must be pressed directly affects the required pressure, and increased interference allowance requires greater pressure. As a guideline you can use to force-fit a cylindrical shaft, the maximum pressure, in tons, should not exceed 7 to 10 times the shaft’s diameter in inches.

As an example of operating a press, we’ll explain how to broach a keyway. Broaching is a machining process that cuts or shears the material by forcing a broach through the part in a single stroke. A broach is a tapered, hardened bar, into which teeth have been cut. The teeth are small at the beginning of the tool and get progressively larger toward the end of the tool. The last several teeth will usually be the correct size of the desired shape. Broaches are available to cut round, square, triangular, and hexagonal holes as well as internal splines and gears and keyways. A



28.33

**Figure 2-38.—Broaching a keyway on a gear.**

keyway broach requires a bushing that will fit snugly in the hole of the part and has a rectangular slot in it to slide the broach through. Shims of different thicknesses are placed behind the broach to adjust the depth of the keyway cut (fig. 2-38).

A broach is a relatively expensive cutting tool and is easily rendered useless if it is not used and handled properly. Like all other cutting tools, store it so no cutting edge is in contact with any object that could chip or dull it. Preparation of the part to be broached is as important as the broaching operation itself. Make the size of the hole so the beginning pilot section enters freely but does not allow the broach to fall freely past the first cutting edge or tooth. If the hole to be broached has flat sides opposite each other, you need only to measure across them and allow for some error from drilling. The broach will sometimes have the drill size printed on it. Be sure the area

around the hole to be broached is perpendicular on both the entry and exit sides.

You will need a considerable amount of pressure to broach, so be sure the setup is rigid and all safety precautions are strictly observed. Use a slow, even pressure to push the broach through the part. That will produce the most accurate and most safe results with the least damage to the broach. Do not bring the broach back up through the hole, push it on through and catch it with a soft cushion of some type. Use a lubricant to broach most metals. They help to cool the tool, wash away chips, and prevent particles from galling or sticking to the teeth.

### **SCREW THREAD INSERTS**

A screw thread insert (called inserts for the remainder of this section) is a helically wound coil designed to screw into an internally threaded hole and

receive a standard-sized externally threaded fastener (fig. 2-39). An insert can be used to repair a threaded hole when the threads have been corroded or stripped away. It also increases thread strength when the base metal of the part is aluminum, zinc, or other soft materials. Before using inserts for a repair job, carefully evaluate the feasibility of using this method. When you have no specific guidance, ask your supervisor and refer to your Type Commander Quality Assurance Manual.

Inserts come in sizes up to 1 1/2-inch in diameter in both American National and Unified, and both coarse and fine thread series. The overall length of an insert is based on a fractional multiple of its major diameter. A 1/2-inch insert is available in lengths of 1/2 inch, 3/4 inch, 1 inch, and so on. Inserts are normally made from stainless steel. However, phosphor bronze and nickel alloy inserts are available by special order.

Several tools are used to install and remove inserts. They are essential if the job is to be done correctly. The most important tool is the tap used to thread the hole that the insert will be screwed into. These taps are oversized by specific amounts according to the size of the insert. The oversize tap should provide a class 2B or 3B when the insert is installed. As an example of the amount of oversize involved, a tap required for a 1/2 - 13 UNC insert has a maximum major diameter of 0.604 inch. Because of the increase in the size of the hole required, be sure there is enough material around the hole on the part to provide strength. A rule of thumb is that the minimum amount of material around the hole should equal the thread size of the insert, measured from the center of the hole. Using this rule, a 1/2 - 13 UNC insert will

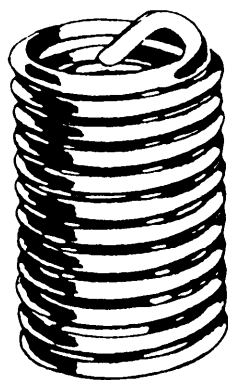


Figure 2-39.—Screw thread insert.

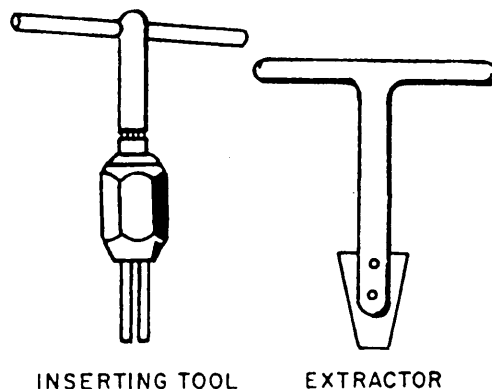


Figure 2-40.—Screw thread insert tools.

require a 1/2-inch distance from the center of the hole to the nearest edge of the part. The tap drill size for each of the taps is marked on the shank of the tap. The diameter of this drill will sometimes vary according to the material being tapped.

The next tool you will use is an inserting tool (fig. 2-40). There are several styles designed for a specific range of insert sizes. Within each of these styles are tools for each size of insert. All of the inserting tools have similar operating characteristics. Either slip the insert over or screw it onto the shank of the tool until the tang (the horizontal strip of metal shown at the top of the insert in figure 2-39) solidly engages the shoulder or recess on the end of the tool. Then, install the insert by turning the tool until the correct depth is reached. Remove the tool by reversing the direction of rotation.

After you have the insert properly installed, break off the tang. This prevents interference with the fastener that will be screwed into the hole. A tang break-off tool is available for all insert sizes of 1/2 inch and below. The tang has a slight notch ground into it that will give way and break when struck with the force of the punch-type, tang break-off tool. On insert sizes more than 1/2 inch, use a long-nosed pair of pliers to move the tang back and forth until it breaks off.

When you must remove a previously installed insert, use an extracting tool (fig. 2-40). There are several different sized tools that cover a given range of insert sizes; be sure you select the right one. Insert the tool into the hole so the blade contacts the top coil of the insert approximately 90° from the beginning of the insert coil. Then, lightly hit the tool to cause the blade to cut into the coil. Turn the tool counter-clockwise until the insert is clear.

The steps involved in repairing a damaged threaded hole with a screw thread insert are as follows:

1. Determine the original threaded hole size. Select the correct standard-sized screw thread insert with the length that best fits the application. Be sure the metal from which the insert is made is recommended for the particular application.

2. Select the correct tap for the insert to be installed. Some taps come in sets of a roughing and a finishing tap.

3. Select the correct size of drill based on the information on the shank of the tap or from charts normally supplied with the insert kits. Measure the part with a rule to determine if the previously referenced minimum distance from the hole to the edge of the part exists. With all involved tools and parts secured rigidly in place, drill the hole to a minimum depth that will permit full threads to be tapped a distance equaling or exceeding the length of the insert, not counting any spot-faced or countersunk area at the top of the hole. Remove all chips from the hole.

4. Tap the hole. Use standard tapping procedures in this step. If the tapping procedure calls for both roughing and finishing taps, be sure to use both taps before you install the insert. Use lubricants to improve the quality of the threads. When you have completed the tapping, inspect the threads to make sure full threads have been cut to the required depth of the hole. Remove all chips.

5. Next, install the insert. If the hole being repaired is corroded badly, apply a small amount of preservative to the tapped threads immediately before installing the insert. Position the insert on the insert tool as required by the particular style being used. Turn the tool clockwise to install the insert. Continue to turn the tool until the insert is approximately 1/2 turn below the surface of the part. Remove the tool by turning it counterclockwise.

6. Use an approved antiseize compound when screwing the threaded bolt or stud into the insert. Avoid using similar metals such as a stainless insert and a stainless bolt to prevent galling and seizing of the threads.

## OXYACETYLENE EQUIPMENT

As an MR, you may have to use an oxyacetylene torch to heat parts to expand them enough to permit

assembly or disassembly. Do this with great care and only with proper supervision. This chapter explains the operation of the oxyacetylene torch used to heat parts only. It also covers the safety precautions you must observe when you use the torch and related equipment.

Oxyacetylene equipment (fig. 2-41) consists of a cylinder of acetylene, a cylinder of oxygen, two regulators, two lengths of hose with fittings, a welding torch with tips, and either a cutting attachment or a separate cutting torch. Accessories include a spark lighter to light the torch; an apparatus wrench to fit the various connections, regulators, cylinders, and torches; goggles with filter lenses to protect the eyes, and gloves to protect the hands. Wear flame-resistant clothing when necessary.

Acetylene ( $C_2H_2$ ) is a fuel gas made up of carbon and hydrogen. When burned with oxygen, acetylene produces a very hot flame with a temperature between  $5700^\circ$  and  $6300^\circ F$ . Acetylene gas is colorless, but has a distinct, easily recognized odor. The acetylene used on board ship is usually taken from compressed gas cylinders.

Oxygen is a colorless, tasteless, odorless gas that is slightly heavier than air. Oxygen will not burn by itself, but it will support combustion when combined with other gases. You must be extremely careful to make sure compressed oxygen does not become contaminated with hydrogen or hydrocarbon gases or liquids, unless the oxygen is controlled by such means as the mixing chamber of a torch. A highly explosive mixture will be formed if uncontrolled compressed oxygen becomes contaminated. NEVER let oxygen come in contact with oil or grease.

The gas pressure in a cylinder must be reduced to a suitable working pressure before it can be used. This is done with a regulator or reducing valve. Regulators are either the single-stage or the double-stage type. Single-stage regulators reduce the pressure of the gas in one step; two-stage regulators do the same job in two steps, or stages. Two-stage regulators generally require less adjustment.

The hose used to make the connection between the torch and the regulators is strong, nonporous, and light and flexible enough to make torch movements easy. The hose is made to withstand high internal pressures. The rubber from which it is made is specially treated to remove sulfur to avoid the danger of spontaneous combustion. Hose is available in various sizes, depending upon work for which it is

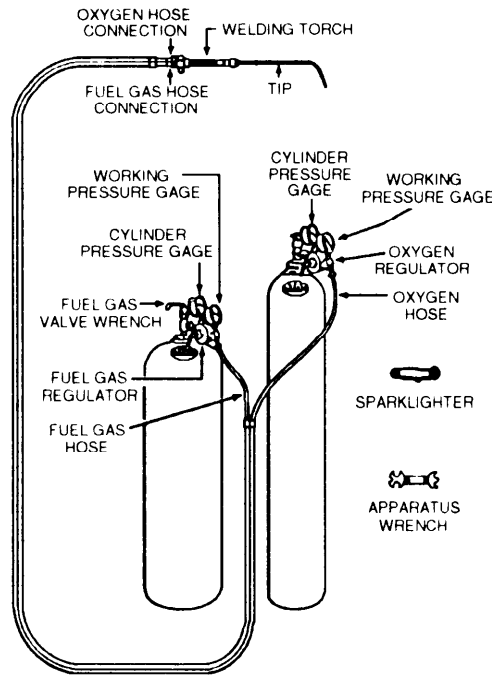


Figure 2-41.—Typical oxyacetylene cylinder bank.

intended. Hose used for light work has a 3/16- or 1/4-inch inside diameter and contains one or two plies of fabric. For heavy-duty welding and handcutting operations, hose with an inside diameter of 1/4 or 5/16 inch and three to five plies of fabric is used. Single hose comes in lengths of 12 1/2 feet to 25 feet. Some manufacturers make a double hose that conforms to the same general specifications. The hoses used for acetylene and oxygen have the same grade, but they differ in color and have different types of threads on the hose fittings. The oxygen hose is GREEN and the acetylene hose is RED. The oxygen hose has right-hand threads and the acetylene hose has left-hand threads to prevent switching hoses during connection.

The oxyacetylene torch is used to mix oxygen and acetylene gas in the proper proportions and to control the volume of these gases burned at the torch tip. Torches have two needle valves, one to adjust the flow of oxygen and the other to adjust the flow of acetylene. In addition, they have a handle (body), two tubes (one for oxygen and one for acetylene), a mixing head, and a tip. Torch tips are made from a special copper alloy that dissipates heat (less than 60 percent copper). They are available in different sizes to handle a wide range of plate thicknesses.

Torch tips and mixers made by different manufacturers differ in design. Some makes of torches have an individual mixing head or mixer for each size of tip. Other makes have only one mixer for several tip sizes. Tips come in various types. Some are one-piece, hard copper tips. Others are two-piece tips that include an extension tube to make connection between the tip and the mixing head. When used with an extension tube, removable tips are made of hard copper, brass, or bronze. Tip sizes are designated by numbers, and each manufacturer has its own arrangement for classifying them. Tips have different hole diameters.

No matter what type or size of tip you select, you must keep the tip clean. Quite often the orifice becomes clogged. When this happens, the flame will not burn properly. Inspect the tip before you use it. If the passage is obstructed, you can clear it with wire tip cleaners of the proper diameter or with soft copper wire. Do not clean tips with machinist's drills or other sharp instruments.

Each different type of torch and tip size requires a specific working pressure to operate properly and safely. You can set pressures by adjusting the regulator gauges to the settings listed on charts provided by the manufacturer.

## SETTING UP OXYACETYLENE EQUIPMENT

Take the following steps to set up oxyacetylene equipment:

1. Secure the cylinders so they cannot be upset. Remove the protective caps.
2. Crack (open) the cylinder valves slightly to blow out any dirt that may be in the valves. Close the valves and wipe the connections with a clean cloth.
3. Connect the acetylene pressure regulator to the acetylene cylinder and the oxygen pressure regulator to the oxygen cylinder. Using the appropriate wrench provided with the equipment, tighten the connecting nuts.
4. Connect the red hose to the acetylene regulator and the green hose to the oxygen regulator. Tighten the connecting nuts enough to prevent leakage.
5. Turn the regulator screws out until you feel little or no resistance, and then open the cylinder valves slowly. Then, open the acetylene valve 1/4 to 1/2 turn. This will allow an adequate flow of acetylene and will allow the valve to be turned off quickly in an emergency. (NEVER open the acetylene cylinder valve more than 1 1/2 turns.) Open the oxygen cylinder valve all the way to eliminate leakage around the stem. (Oxygen valves are double seated or have diaphragms to prevent leakage when open.) Read the high-pressure gauge to check the pressure of each cylinder.
6. Blow out the oxygen hose by turning the regulator screw in and then back out again. If you need to blow out the acetylene hose, do it ONLY in a well-ventilated place that is free from sparks, flames, or other possible sources of ignition.
7. Connect the hoses to the torch. Connect the red acetylene hose to the connection gland that has the needle valve marked AC or ACET. Connect the green oxygen hose to the connection gland that has the needle valve marked OX. Test all hose connections for leaks by turning both regulator screws IN, while the needle valves are closed. Then, turn the regulator screws OUT, and drain the hose by opening the needle valves.
8. Adjust the tip. Screw the tip into the mixing head and screw the mixing head onto the torch body. Tighten the mixing head/tip assembly by hand and

adjust the tip to the proper angle. Secure this assembly with the wrench provided with the torch.

9. Adjust the working pressures. Adjust the acetylene pressure by turning the acetylene gauge screw to the right. Adjust the acetylene regulator to the required working pressure for the particular tip size. (Acetylene pressure should NEVER exceed 15 psig.)

10. Light and adjust the flame. Open the acetylene needle valve on the torch and light the acetylene with a spark lighter. Keep your hand out of the way. Adjust the acetylene valve until the flame just leaves the tip face. Open and adjust the oxygen valve until you get the proper neutral flame. Notice that the pure acetylene flame that just leaves the tip face is drawn back to the tip face when the oxygen is turned on.

## ADJUSTING THE FLAME

A pure acetylene flame is long and bushy and has a yellowish color. It is burned by the oxygen in the air that is not sufficient to burn the acetylene completely. Therefore, the flame is smoky, producing a soot of fine, unburned carbon. The pure acetylene flame is unsuitable for use. When the oxygen valve is opened, the mixed gases burn in contact with the tip face. The flame changes to a bluish-white color and forms a bright inner cone surrounded by an outer flame envelope. The inner cone develops the high temperature required.

The type of flame commonly used to heat parts is a neutral flame. The neutral flame is produced by burning 1 part of oxygen with 1 part of acetylene. The bottled oxygen, together with the oxygen in the air, produces complete combustion of the acetylene. The luminous white cone is well-defined and there is no greenish tinge of acetylene at its tip, nor is there an excess of oxygen. A neutral flame is obtained by gradually opening the oxygen valve to shorten the acetylene flame until a clearly defined inner luminous cone is visible. This is the correct flame to use for many metals. The temperature at the tip of the inner cone is about 5900°F, while at the extreme end of the outer cone it is only about 2300°F. This gives you a chance to exercise some temperature control by moving the torch closer to or farther from the work.



## EXTINGUISHING THE FLAME

To extinguish the oxyacetylene flame and to secure equipment after completing a job, or when work is to be interrupted temporarily, you should take the following steps:

1. Close the acetylene needle valve first; this extinguishes the flame and prevents flashback. (Flashback is discussed later.) Then, close the oxygen needle valve.
2. Close both the oxygen and acetylene cylinder valves. Leave the oxygen and acetylene regulators open temporarily.
3. Open the acetylene needle valve on the torch and allow gas in the hose to escape for 5 to 15 seconds. Do NOT allow gas to escape into a small or closed compartment. Close the acetylene needle valve.
4. Open the oxygen needle valve on the torch. Allow gas in the hose to escape for 5 to 15 seconds. Close the valve.
5. Close both oxygen and acetylene cylinder regulators by backing out the adjusting screws until they are loose.

Follow this procedure whenever your work will be interrupted for an indefinite period. If you stop work for only a few minutes, you don't need to secure the cylinder valves and drain the hoses. However, if you stop for an indefinite time, follow the entire extinguishing and securing procedure. For overnight work stoppage in areas other than the shop, it is a good idea to remove the pressure regulators and the torch from the system. Double check the cylinder valves to make sure they are closed securely.

## SAFETY: OXYACETYLENE EQUIPMENT

When you are heating with oxyacetylene equipment, you must observe certain safety precautions to protect personnel and equipment from injury by fire or explosion. The precautions that follow apply specifically to oxyacetylene work.

- Use only approved apparatus that has been examined and tested for safety.
- When you use cylinders, keep them far enough away from the actual heating area so they will not be reached by the flame or sparks from the object being heated.

- NEVER interchange hoses, regulators, or other apparatus intended for oxygen with those intended for acetylene.

- Keep valves closed on empty cylinders.
- Do NOT stand in front of cylinder valves while opening them.
- When a special wrench is required to open a cylinder valve, leave the wrench in position on the valve stem while you use the cylinder so the valve can be closed rapidly in an emergency.
- Always open cylinder valves slowly. (Do NOT open the acetylene cylinder valve more than 1 1/2 turns.)
- Close the cylinder valves before moving the cylinders.
- NEVER try to force unmatching or crossed threads on valve outlets, hose couplings, or torch valve inlets. These threads are right-handed for oxygen and left-handed for acetylene. The threads on acetylene cylinder valve outlets are right-handed, but have a pitch that is different from the pitch of the threads on the oxygen cylinder valve outlets. If the threads do not match, the connections are mixed.
- Always use the correct tip or nozzle and the correct pressure for the particular work involved. This information should be taken from tables or worksheets supplied with the equipment.
- Do NOT allow acetylene and oxygen to accumulate in confined spaces. Such a mixture is highly explosive.
- Keep a clear space between the cylinder and the work so the cylinder valves may be reached quickly and easily if necessary.
- When lighting the torch, use friction lighters, stationary pilot flames, or some other suitable source of ignition. The use of matches may cause serious hand burns. Do NOT light a torch from hot metal. When lighting the torch, open the acetylene valve first and ignite the gas with the oxygen valve closed. Do NOT allow unburned acetylene to escape into a small or closed compartment.
- When extinguishing the torch, close the acetylene valve first and then close the oxygen valve.
- Do NOT use lubricants that contain oil or grease on oxyacetylene equipment. OIL OR

**GREASE IN THE PRESENCE OF OXYGEN UNDER PRESSURE WILL IGNITE VIOLENTLY.** Consequently, do not let oxygen come in contact with these materials in any way. Do NOT handle cylinders, valves, regulators, hose, or any other apparatus that uses oxygen under pressure with oily hands or gloves. Do NOT permit a jet of oxygen to strike an oily surface or oily clothes.

**NOTE:** A suitable lubricant for oxyacetylene equipment is glycerin.

- NEVER use acetylene from cylinders without reducing the pressure through a suitable pressure reducing regulator. Avoid acetylene working pressures in excess of 15 pounds per square inch. Oxygen cylinder pressure must likewise be reduced to a suitable low working pressure; high pressure may burst the hose.

- Stow all cylinders carefully according to prescribed procedures. Store cylinders in dry, well-ventilated, well-protected places away from heat and combustible materials. Do NOT stow oxygen cylinders in the same compartment with acetylene cylinders. Stow all cylinders in an upright position. If they are not stowed in an upright position, do not use them until they have been allowed to stand upright for at least 2 hours.

- Do not use the torch to heat material without first making certain that hot sparks or hot metal will not fall on your legs or feet, on the hose and cylinder, or on any flammable materials. Be sure a fire watch is posted as required to prevent accidental fires.

- Be sure you and anyone nearby wear flameproof protective clothing and shaded goggles to prevent serious burns to the skin or the eyes. A No. 5 or 6 shaded lens should be sufficient for your heating operations.

- Welding, heating and cutting operations generate metal fumes, smoke and carbon monoxide. Use adequate ventilation, such as a local exhaust hood, to remove fumes and smoke. When ventilation is not available, operators should wear metal fume respirators. Your Safety Officer will specify what type of respirator you need.

These precautions are by no means all the safety precautions that pertain to oxyacetylene equipment, and they only supplement those specified by the

manufacturer. Always read the manufacturer's manual, *Naval Ships' Technical Manual, Navy Occupational Safety and Health (NAVOSH) Program Manual For Forces Afloat*, (OPNAV) INSTRUCTION 5100.19B, and adhere to all precautions and procedures for the specific equipment you are going to be using.

## **BACKFIRE AND FLASHBACK**

Backfire and a flashback are two common problems encountered in using an oxyacetylene torch. Unless the system is thoroughly purged of air and all connections in the system are tight before the torch is ignited, the flame is likely to burn inside the torch instead of outside the tip. The difference between backfire and flashback is that in a backfire, there is a momentary burning back of the flame into the torch tip; in a flashback, the flame burns in or beyond the torch mixing chamber. A backfire is characterized by a loud snap or pop as the flame goes out. A flashback is usually accompanied by a hissing or squealing sound. At the same time, the flame at the tip becomes smoky and sharp-pointed. When a flashback occurs, immediately shut off the torch oxygen valve, then close the acetylene valve.

A flashback indicates that something is radically wrong either with the torch or with the manner of handling it. A backfire is less serious. Usually the flame can be relighted without difficulty. If backfiring continues whenever the torch is relighted, check for an overheated tip, gas working pressures greater than that recommended for the tip size being used, a loose tip, or dirt on the torch tip seat. These same difficulties may be the cause of a flashback, except that the difficulty is present to a greater degree. For example, the torch head may be distorted or cracked.

In most instances, backfires and flashbacks result from carelessness. To avoid these difficulties, always make certain (1) all connections in the system are clean and tight, (2) torch valves are closed (not open or merely loosely closed) when the equipment is stowed, (3) the oxygen and acetylene working pressures used are those recommended for the torch, and (4) you have purged the system of air before using it. Purging the system of air is especially necessary when the hose and torch have been newly connected or when a new cylinder is put into the system.